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Using PDCA- Based Quality Improvement to Reduce Needle Stick Injuries in a Tertiary Healthcare Facility

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Abstract:

- ***Background:***

Needlestick injuries (NSIs) remain a significant occupational hazard in healthcare, exposing healthcare workers (HCWs) to bloodborne pathogens and generating substantial clinical and economic burden. Despite established infection prevention policies, NSIs continue to occur due to behavioral, procedural, environmental and system-level gaps. Evidence on structured quality improvement (QI) interventions for NSI reduction in the UAE remains limited.

- ***Objective:***

To evaluate the effectiveness of a structured FOCUS–PDCA–based QI intervention in reducing NSI incidence, improving compliance and knowledge related to sharps safety, and reducing post-exposure prophylaxis (PEP)–related costs in a tertiary healthcare facility.

- ***Methods:***

A retrospective pre–post interventional study was conducted in a tertiary teaching hospital in Sharjah, UAE. Baseline data (January–December 2024) were compared with post-intervention data following implementation of a multidisciplinary FOCUS–PDCA intervention (January–December 2025). Interventions included policy revision, staff education, introduction of safety-engineered devices, puncture-resistant sharps containers, and monthly compliance audits. NSI rates per 100 full-time equivalents (FTE), compliance with sharps-handling practices, staff knowledge scores, and exposure-management costs were analyzed using descriptive statistics and Poisson rate-ratio testing ($\alpha = 0.05$).

- ***Results:***

Overall NSI incidence decreased from 3.68 to 1.06 per 100 FTE, representing a 71% relative reduction (rate ratio [RR] = 0.29; 95% CI 0.16–0.54; $p < 0.001$). Statistically significant reductions were observed in high-risk areas, including Emergency and Critical Care units. Compliance with safe sharps-handling practices improved from 38.3% to 88.3% ($p < 0.001$), and post-training knowledge scores increased significantly across all departments. Total NSI-related management costs decreased by 60.7%, yielding absolute savings of AED 101,010.4.

- ***Conclusion:***

Implementation of a structured PDCA-based QI approach resulted in significant, sustained reductions in NSI rates, marked improvements in compliance and knowledge, and substantial cost savings. This study demonstrates the effectiveness of systematic, multimodal QI interventions for occupational safety and supports broader adoption of PDCA-driven sharps-safety programs in healthcare settings.

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Keywords: *Needlestick Injuries; Quality Improvement; PDCA; Sharps Safety; Occupational Health; Healthcare Workers.*

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I. INTRODUCTION

➢ *Rationale and Background Information*

Needle stick injuries (NSIs) remain a major occupational hazard in healthcare settings, exposing healthcare workers (HCWs) to blood-borne pathogens such as hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV). These injuries contribute not only to the transmission of infectious diseases but also to psychological distress, work absenteeism, and increased healthcare costs. Global estimates indicate that millions of HCWs experience percutaneous injuries annually, highlighting the persistent threat NSIs pose to healthcare systems worldwide [1]. Within the UAE, this issue remains a local priority, and this project aligns with the UAE Ministry of Health and Prevention's (MOHAP) occupational health and safety objectives by promoting safety-engineered devices, standardized sharps disposal, and competency-based training.

Despite established infection control protocols, NSIs continue to occur due to improper sharps handling, inadequate disposal practices, and inconsistent compliance with safety procedures. In our tertiary healthcare facility, 46 NSI cases were reported in 2024, with most incidents occurring among nurses and doctors during procedures, blood collection, and medication administration. High-risk areas included the Emergency Department and Operating Theatres, underscoring the presence of behavioral, procedural, and system-level gaps requiring targeted quality improvement interventions.

Quality improvement (QI) methodologies—particularly the Plan-Do-Check-Act (PDCA) cycle—are widely recognized for reducing occupational hazards in healthcare settings. Multiple studies have shown that structured interventions, including education, engineering controls, and strong policy enforcement, are effective in reducing NSI rates [2]. A meta-analysis by Tarigan et al. demonstrated that training alone can reduce NSIs by 34%, safety-engineered devices (SEDs) by 49%, and combined strategies by 62%, emphasizing the superiority of multimodal approaches [2].

International guidelines further reinforce these strategies. The World Health Organization (WHO) recommends universal adoption of safety-engineered syringes, minimizing unnecessary injections, and integrating sharps safety programs into institutional infection control policies [3]. Similarly, the Centers for Disease Control and Prevention (CDC) provides comprehensive guidance on sharps safety and the prevention of occupational exposures in healthcare settings [4]. Evidence from cost-effectiveness studies also demonstrates that investments in SEDs and training are offset by reductions in post-exposure prophylaxis expenses, laboratory testing, and associated productivity losses [5].

Despite substantial global evidence, there remains a scarcity of UAE-specific research evaluating the impact of structured QI interventions—particularly PDCA-based strategies—on NSI reduction. This gap highlights the importance of locally driven studies to generate context-appropriate solutions and support national occupational safety initiatives. Collectively, the available evidence highlights that NSI prevention requires a multifaceted approach combining education, engineering controls, and continuous monitoring within a structured QI framework. Sustained leadership support and a strong culture of safety are essential for long-term success.

II. METHODOLOGY

➢ *Study Design:*

This study utilized a retrospective, pre-post interventional design within a Quality Improvement (QI) framework using the FOCUS-PDCA (Plan-Do-Check-Act) methodology. The design was chosen to assess the effectiveness of structured interventions in reducing needle stick injuries (NSIs) among healthcare workers in a tertiary-level teaching healthcare facility. A retrospective design was selected because it allows the use of existing incident-reporting data, enables comparison of pre- and post-intervention trends, and is practical for evaluating real-world QI initiatives without disrupting clinical workflow.

➢ *Study Setting and Population:*

The study was conducted at a tertiary-level teaching hospital in Sharjah, UAE. The population included all healthcare workers (HCWs) at risk of occupational exposure to sharps, such as staff nurses, doctors, technicians, interns, and housekeeping staff. High-risk clinical areas such as the Emergency Department (A/E), Operating Theatres (OT), and Intensive Care Units (ICUs) were prioritized for intervention.

➢ *Sample Size:*

All reported NSI cases during the baseline and intervention periods were included, representing a complete census rather than a sampled population. This approach ensures full capture of incident trends and eliminates sampling bias. The sample size is therefore determined by the total number of NSIs reported through the hospital's occupational health and incident-reporting system.

➢ *Study Period:*

- Baseline Phase: January to December 2024 (pre-intervention data collection).

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- Intervention Phase: January to March 2025 (post-intervention monitoring and evaluation: March 2025 to Dec 2025).

➢ *Inclusion Criteria*

- All healthcare workers (HCWs) at risk of occupational exposure to sharps, including staff nurses, doctors, technicians, interns, and housekeeping staff.
- Employees working in high-risk clinical areas such as Emergency Department, Operating Theatres, Intensive Care Units, and Medical/Surgical Wards.
- NSI incidents reported during the study period (Baseline: January–December 2024; Intervention: January–March 2025).
- Staff who provided informed consent for participation in training and educational interventions.

➢ *Exclusion Criteria*

- Administrative and non-clinical staff with no exposure to sharps or invasive procedures.
- NSI incidents occurring outside the hospital premises or unrelated to clinical duties.
- Incomplete or missing data in NSI incident reports that cannot be verified.
- Staff on extended leave or not actively involved in patient care during the study period.

➢ *Bias Mitigation Strategies:*

To minimize reporting bias, the study relied on mandatory institutional NSI reporting procedures, cross-checking incident logs with occupational health records. Observer bias was reduced by using standardized audit tools and predefined assessment criteria. Training assessments were conducted anonymously to reduce social desirability bias.

➢ *Handling of Missing Data:*

Missing or incomplete NSI reports were reviewed and verified through occupational health records, supervisor documentation, or follow-up clarification when possible. Cases with unverifiable or incomplete data were excluded based on predefined exclusion criteria to maintain data integrity.

➢ *Data Security:*

All data handling adheres to institutional IT security and UAE data protection requirements, with role-based access controls, encrypted storage, and audit trails for data retrieval.

➢ *Intervention Framework (FOCUS-PDCA):*

- Find an Opportunity: High NSI incidence (46 cases in 2024) identified as a critical safety concern.
- Organize a Team: Multidisciplinary team including Infectious Diseases Physician and Infection Control Manager, Quality & Patient Safety Manager, Nursing Leadership, and Environmental Services.
- Clarify the Process: Review of existing sharps handling and disposal practices; gap analysis against Ministry of Health standards.
- Understand the Problem: Root cause analysis identified improper sharp disposal, inadequate training, and lack of safety devices as major contributors.
- Select an Outcome: Targeted ≥25% reduction in NSI cases within 9 months.
- *Timeline for FOCUS Phase:* Completed within the first 4 weeks of the project (January 2025).

➢ *PDCA Cycle Implementation:*

- *Plan (January–February 2025):*

✓ Policy revision on sharps handling and occupational exposure management.
✓ Development of training modules and awareness materials.
✓ *KPIs:*

▪ Completion of revised sharps safety policy (100% by February 2025).
▪ Development of training materials and posters (100% by February 2025).

- *Do (March–May 2025):*

✓ Conducted staff education sessions on safe sharps handling, one-hand scoop method, and PPE use.
✓ Introduced safety-engineered devices and puncture-resistant sharps containers.
✓ Displayed awareness posters and distributed brochures across departments.
✓ *KPIs:*

▪ –≥90% of HCWs trained by end of May 2025.
▪ 100% replacement of sharps containers with puncture-resistant models in high-risk areas.
▪ Deployment of safety-engineered devices in ≥80% of clinical units.

- *Check (Monthly: March–September 2025):*

✓ Monthly audits of sharps disposal practices.
✓ Monitoring NSI trends and compliance with infection control protocols.
✓ *KPIs:*

▪ Monthly compliance rate ≥85% for correct sharps disposal.
▪ Monthly NSI rate reduction trend of ≥5% compared to baseline.
▪ Audit completion rate of 100% each month.

- *Act (September 2025 Onward):*

✓ Reinforcement of best practices through reminders and feedback loops.
✓ Sustained policy updates and continuous education programs.

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✓ *KPIs:*

- Integration of sharps safety training into annual competency assessments (100%).
- Quarterly refresher sessions conducted for ≥80% of staff.
- Sustained NSI reduction of ≥40% by end of 2025.
- Sustainability KPI—Maintain ≥90% compliance on sharps disposal audits for two consecutive quarters post-intervention; investigate and rectify any unit falling below threshold within one month.

➢ *Data Management and Statistical Analysis*

All data related to needle stick injuries (NSIs) were collected from the hospital's Infection Control and Occupational Health records using a standardized data collection tool to ensure accuracy and consistency. To maintain confidentiality, all data were anonymized and securely stored in password-protected files accessible only to the research team.

- *The Dataset Included Key Variables Such as:*

✓ Type of exposure (e.g., needle stick, splash, cut wound)
✓ Job category (e.g., nurse, doctor, technician)
✓ Clinical area (e.g., Emergency Department, ICU)
✓ Cause of injury
✓ Post-exposure prophylaxis (PEP) details

Data were compiled using Microsoft Excel and analyzed using SPSS software (version 27.0). Descriptive statistics were used to summarize NSI trends, including frequency, distribution by job role, and high-risk areas.

Comparative analysis was conducted to assess differences between the pre-intervention (2024) and post-intervention (2025) phases. To determine whether observed changes were statistically meaningful, statistical significance was defined using a p-value threshold of < 0.05. This means that if the p-value is less than 0.05, there is less than a 5% probability that the results occurred by chance, indicating that the intervention likely had a real effect.

- *This Statistical Approach was Applied to Evaluate:*

✓ Changes in NSI incidence rates
✓ Compliance with infection control practices
✓ Staff knowledge improvement based on pre- and post-training assessments

The results were presented in tables and visualized using bar charts and pie charts to clearly illustrate trends and differences across time periods and staff categories. Analyses performed using licensed SPSS (v27) per hospital IT policy; calculation sheets and syntax files will be archived to ensure reproducibility.

III. RESULTS

Across all departments, the overall event rate decreased from 3.68 to 1.06 per 100 FTE (absolute change −2.61, relative reduction 71%) (Figure 01) (Table 01) . At the departmental level, statistically significant reductions were observed in Accident & Emergency and Critical Care, where event rates decreased from 10.13 to 3.23 per 100 FTE (rate ratio 0.32, $p = 0.026$) and 2.56 to 0.26 per 100 FTE (rate ratio 0.10, $p = 0.030$), respectively. These represented the largest and most statistically robust declines.

Other departments demonstrated numeric reductions that did not reach statistical significance: Medical & Surgical decreased from 2.49 to 1.18 (rate ratio 0.47, $p = 0.130$); OT & Cath Lab from 4.58 to 0.78 (rate ratio 0.17, $p = 0.102$); and Phlebotomy from 2.00 to 0.00 (rate ratio 0.34, $p = 0.509$). While these departments showed notable relative improvements, the changes were not statistically significant—likely due to low event counts and limited statistical power.

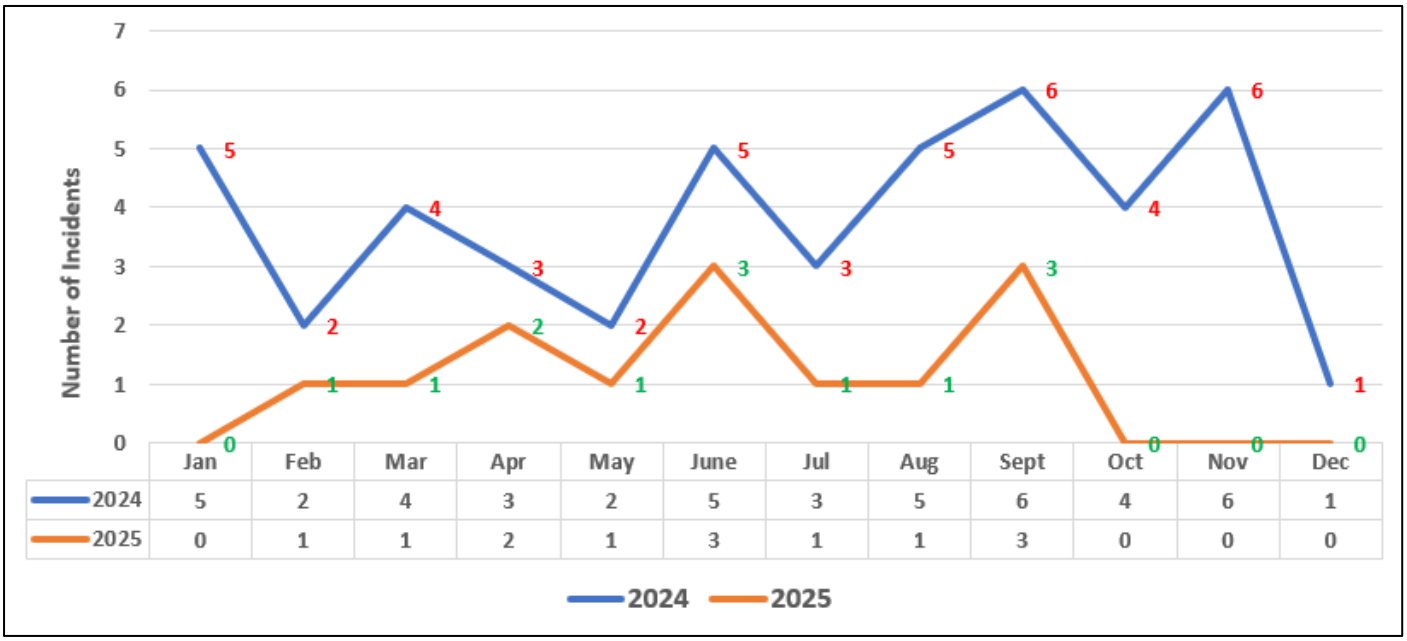

Fig 1 Trend of Monthly NSI Rates: 2024 Compared with 2025

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Table 1 Pre- and Post-Intervention Event Rates Per 100 FTE with Rate Ratios, Confidence Intervals, and p Values

Department	Pre events	Pre FTE	Pre rate/100	Post events	Post FTE	Post rate/100	Rate ratio (Post/Pre)	95% CI (RR)	p-value
Accident & Emergency	16	158	10.13	5	155	3.23	**0.32**	0.12–0.87	**0.026**
Critical Care Departments	10	390	2.56	1	380	0.26	**0.1**	0.01–0.80	**0.03**
Medical & Surgical Departments	13	522	2.49	6	509	1.18	0.47	0.18–1.25	0.13
OT & Cath Lab	6	131	4.58	1	128	0.78	0.17	0.02–1.42	0.102
Phlebotomy	1	50	2	0	49	0	0.34	0.01–8.35	0.509
Overall	**46**	**1,251**	**3.68**	**13**	**1,221**	**1.06**	**0.29**	**0.16–0.54**	**<0.001**

Abbreviations: FTE = Full-Time Employee; RR = Rate Ratio.

Across job categories, (Table 2) the overall event rate decreased from 3.68 to 1.06 per 100 FTE (RR = 0.29, 95% CI 0.16–0.54; $p < 0.001$). Among specific groups, nurses showed a statistically significant reduction from 4.82 to 1.01 per 100 FTE (RR = 0.21, 95% CI 0.09–0.47; $p < 0.001$). Reductions in doctors (3.17 to 1.83 per 100 FTE; RR = 0.58, 95% CI 0.17–1.97; $p = 0.380$), house keeping (2.67 to 1.33 per 100 FTE; RR = 0.50, 95% CI 0.09–2.73; $p = 0.423$), and technicians (0.57 to 0.00 per 100 FTE; RR = 0.37, 95% CI 0.01–9.01; $p = 0.539$) were not statistically significant, likely reflecting low event counts and limited precision.

Table 2 Job-Category Differences in Pre- and Post-Intervention Event Rates with Associated Rate Ratios and p Values

Job Category	Pre events	Pre FTE	Pre rate/100	Post events	Post FTE	Post rate/100	Rate ratio (Post/Pre)	95% CI (RR)	p-value
Doctors	7	221	3.17	4	219	1.83	0.58	0.17–1.97	0.38
Nurses	34	706	4.82	7	694	1.01	**0.21**	**0.09–0.47**	**<0.001**
House Keeping	4	150	2.67	2	150	1.33	0.5	0.09–2.73	0.423
Technicians	1	174	0.57	0	158	0	0.37	0.01–9.01	0.539
Overall	**46**	**1,251**	**3.68**	**13**	**1,221**	**1.06**	**0.29**	**0.16–0.54**	**<0.001**

Abbreviations: FTE = Full-Time Employee; RR = Rate Ratio.

Across standardized reasons,(Table 3) the overall event rate decreased from 3.68 to 1.06 per 100 FTE (RR = 0.29, 95% CI 0.16–0.54; $p < .001$). The only category showing an increase was *accidental contact during patient care* (0.80 to 1.06 per 100 FTE; RR = 1.33, 95% CI 0.58–3.04; $p = .496$), which was not statistically significant. A statistically significant reduction was observed for injuries *during surgical/operative procedures involving sharps* (RR = 0.05, 95% CI 0.00–0.93; $p = .044$). Reductions for *blood collection/arterial sampling* (RR = 0.06, 95% CI 0.00–1.04; $p = .054$) and *IV cannulation/flushing/central line handling* (RR = 0.06, 95% CI 0.00–1.04; $p = .054$) were borderline and not significant at $\alpha = .05$, while other categories showed non-significant declines with wide confidence intervals, consistent with low event counts.

Table 3 Pre-and Post-Intervention Event Rates Per 100 FTE by Standardized Reason with Rate Ratios, 95% Confidence Intervals, and p Values

Reason (standardized category)	Pre events	Pre FTE	Pre rate/100	Post events	Post FTE	Post rate/100	Rate ratio (Post/Pre)	95% CI (RR)	p-value
Accidental contact with a sharp object during patient care	10	1,251	0.8	13	1,221	1.06	1.33	0.58–3.04	0.496
During surgical or operative procedures involving sharps	9	1,251	0.72	0	1,221	0	**0.05**	**0.00–0.93**	**0.044**
During blood collection or arterial blood sampling	8	1,251	0.64	0	1,221	0	0.06	0.00–1.04	0.054
IVcannulation/flushing/central line insertion or handling	8	1,251	0.64	0	1,221	0	0.06	0.00–1.04	0.054
During or immediately after injection administration	5	1,251	0.4	0	1,221	0	0.09	0.01–1.68	0.108
Improper sharps disposal or waste handling	2	1,251	0.16	0	1,221	0	0.2	0.01–4.27	0.306
Dental procedure involving sharps	2	1,251	0.16	0	1,221	0	0.2	0.01–4.27	0.306

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Sudden patient movement or patient-related aggression	1	1,251	0.08	0	1,221	0	0.34	0.01–8.38	0.511
Blood/body fluid splash to mucous membranes	1	1,251	0.08	0	1,221	0	0.34	0.01–8.38	0.511
Overall	**46**	**1,251**	**3.68**	**13**	**1,221**	**1.06**	**0.29**	**0.16–0.54**	**<0.001**

Two-Sample Poisson Rate-Ratio z-Test (Two-Sided α = .05). A Continuity Correction of 0.5 was Applied when a Period's Count was Zero. Rates are Per 100 FTE.

- *Notes: RR = Rate Ratio.*

The intervention met and exceeded the objective of a ≥20% increase in healthcare workers' compliance with infection control and safe sharps-handling protocols within six months (Table 4) . Overall compliance improved from 38.3% to 88.3% (absolute improvement 50.0 pp, 95% CI 41.5 to 58.5; $p < .001$), corresponding to a 130.4% relative improvement. All units demonstrated large, statistically significant gains (each $p < .001$). The largest absolute improvement was observed in Phlebotomy (+53.3 pp, 95% CI 33.0 to 73.6), with Emergency, OT, Dialysis, ICUs, and Medical/Surgical ward each showing +46.7 to +50.0 pp improvements with confidence intervals excluding zero. Consequently, the target was achieved in every unit.

Table 4 Pre- and Post-Intervention Compliance with Infection Control and Safe Sharps-Handling Protocols by Unit

Unit/Department	Pre compliant (n/N)	Pre compliance %	Post compliant (n/N)	Post compliance %	Absolute improvement, pp	95% CI for improvement, pp	Relative improvement %	p-value
Emergency department	12/30	40	26/30	**86.7**	**46.7**	25.3 to 68.0	116.7	**<0.001**
OT	10/30	33.3	25/30	**83.3**	**50**	28.5 to 71.5	150	**<0.001**
Dialysis	12/30	40	27/30	**90**	**50**	29.4 to 70.6	125	**<0.001**
Intensive care units	13/30	43.3	28/30	**93.3**	**50**	30.1 to 69.9	115.4	**<0.001**
Medical and Surgical ward	11/30	36.7	26/30	**86.7**	**50**	28.9 to 71.1	136.4	**<0.001**
Phlebotomy	11/30	36.7	27/30	**90**	**53.3**	33.0 to 73.6	145.5	**<0.001**
Overall	**69/180**	**38.3**	**159/180**	**88.3**	**50**	**41.5 to 58.5**	**130.4**	**<0.001**

- *Note. Values Represent Compliance Measured During Structured Audits. Absolute Improvement is Shown in Percentage Points (pp). Bold p-Values Indicate Statistical Significance at α = .05.*

Subgroup analysis (Table 5) by department demonstrated consistently significant improvements in knowledge scores following the intervention. All departments with adequate sample sizes showed large, statistically significant gains—for example, Critical Care increased by +5.95 points (95% CI 5.07 to 6.83, $p < .001$) and the Outpatient Department by +5.18 points (95% CI 4.23 to 6.13, $p < .001$). The largest improvement was observed in the Laboratory group (+8.25 points, 95% CI 5.86 to 10.64, $p = .002$) despite its small sample size. Across all departments, the proportion of participants achieving a "High" knowledge level rose to 100% post-training, with McNemar's tests indicating statistically significant gains in all sizeable groups (e.g., Critical Care, Outpatient, Operation Theatre; $p < .001$). Overall, the intervention produced robust and consistent improvements in knowledge across all clinical areas.

Table 5 Analysis of Pre- and Post-Training Knowledge with p Values and 95% CIs

Department	N	Pre mean (SD)	Post mean (SD)	Mean change (95% CI)	p (t-test)	Pre High %	Post High %	Δ High (pp)	McNemar p
Laboratory	4	1.75 (1.50)	10.00 (0.00)	**+8.25** (5.86 to 10.64)	**0.002**	0	100	100	0.125
Medical	10	3.60 (3.95)	10.00 (0.00)	**+6.40** (3.57 to 9.23)	**<0.001**	20	100	80	0.008
Interns	16	3.69 (3.82)	10.00 (0.00)	**+6.31** (4.27 to 8.35)	**<0.001**	12.5	100	87.5	**<0.001**

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Critical care Department	62	4.05 (3.47)	10.00 (0.00)	**+5.95** (5.07 to 6.83)	**<0.001**	14.5	100	85.5	**<0.001**
Operation theatre	25	4.08 (3.96)	10.00 (0.00)	**+5.92** (4.29 to 7.55)	**<0.001**	16	100	84	**<0.001**
Surgeon	10	4.40 (3.92)	10.00 (0.00)	**+5.60** (2.79 to 8.41)	**0.001**	20	100	80	0.008
Accident and emergency	20	4.80 (3.38)	10.00 (0.00)	**+5.20** (3.62 to 6.78)	**<0.001**	15	100	85	**<0.001**
Out Patient Department	56	4.82 (3.56)	10.00 (0.00)	**+5.18** (4.23 to 6.13)	**<0.001**	21.4	100	78.6	**<0.001**
General Surgery	2	5.00 (2.83)	10.00 (0.00)	+5.00 (−20.41 to 30.41)	0.242	0	100	100	0.5
Medical and Surgical department	70	5.17 (3.21)	10.00 (0.00)	**+4.83** (4.06 to 5.59)	**<0.001**	15.7	100	84.3	**<0.001**

Methods summary. Mean score change was tested with a paired t-test (two-sided, α = .05), and 95% CIs are t-based for the mean paired difference. "High knowledge" (pre/post) was analyzed as a paired binary outcome using McNemar's exact test on discordant pairs; we report absolute percentage-point (pp) change and McNemar p

From 2024 to 2025, the number of exposures decreased from 46 to 13 (−71.7%), and the total management cost dropped from AED 166,303.8 to AED 65,293.4 (−60.7%; absolute saving AED 101,010.4) (Table 6) (Figure 1). The largest cost reductions were observed for patient/source positive or unknown & immuned staff (11 to 5 cases; −AED 46,134) and patient/source negative & non-immuned staff (5 to 2 cases; −AED 40,272.6), with complete elimination of patient/source positive or unknown & non-immuned staff cases (1 to 0; −AED 14,603.75). Although overall costs fell, the average cost per incident increased (from ~AED 3,615 to ~AED 5,023) due to a case-mix shift—the proportion of zero-cost "patient/source negative & immuned" incidents declined (28/46 to 6/13). In 2025, costs were primarily driven by positive/unknown & immuned (AED 38,445; 59%) and negative & non-immuned (AED 26,848.4; 41%) cases, with per-case unit costs unchanged from 2024.

Table 6 Cost Comparison and Percentage Reduction (2024 → 2025)

Category	2024 Cost (AED)	2025 Cost (AED)	Absolute Change (AED)	Cost Reduction % (vs 2024)
Cut wound from In animate object	0	0	0	—
Patient/ Source Serology Negative and Immuned staff	0	0	0	—
Patient/ Source Serology Positive + Unknown Source and Immuned staff	84579	38445	-46134	54.5
Patient/ Source Serology Positive + Unknown Source and non - Immuned staff	14603.75	0	-14603.75	100
Patient/Source Serology Negative and Non-Immuned staff	67121	26848.4	-40272.6	60
Grand Total	166303.8	65293.4	-101010.4	60.7

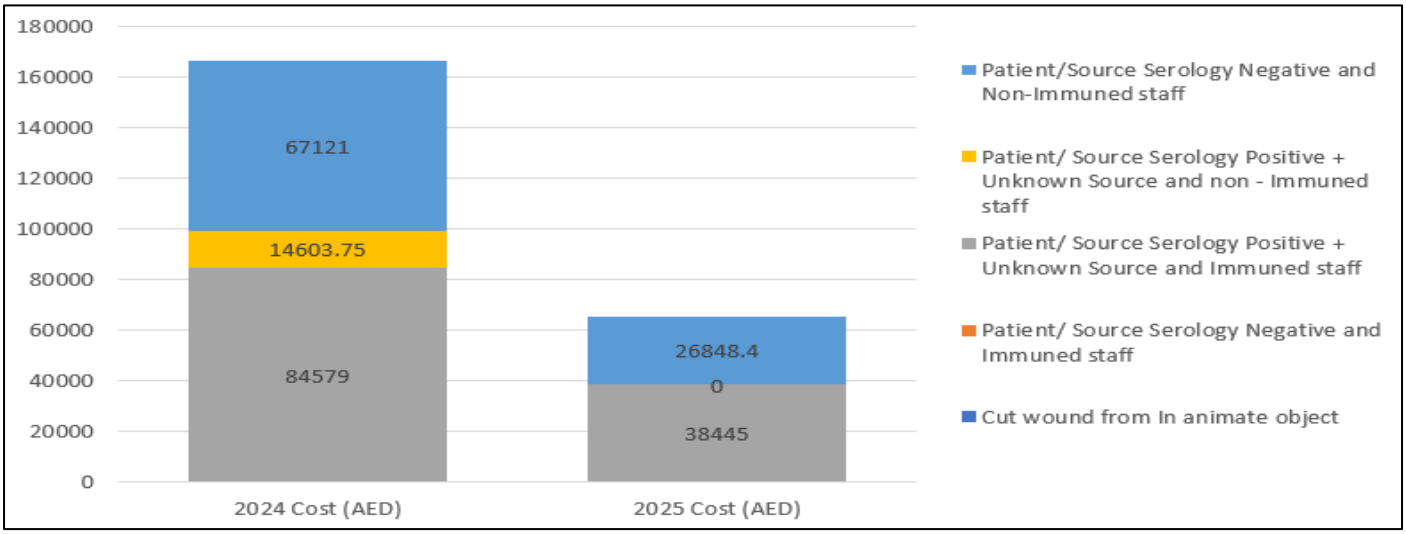

Fig 2 Exposure Management Cost Breakdown by Category: 2024 vs 2025

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Figure 2 shows monthly NSI rates for 2024 and 2025 with intervention overlay. Online trainings were initiated in September 2024 and November 2024. In 2025, PDSA phases included PLAN (Jan–Feb), DO (Mar–May), CHECK (Mar–Sept), and ACT (Sept–Dec). KPIs: revised policy and training materials completed by Feb 2025; ≥90% HCWs trained by May; 100% replacement of puncture-resistant sharps containers in high-risk areas; safety-engineered devices in ≥80% units; monthly audits with ≥85% compliance and ≥5% monthly NSI reduction; sustained ≥40% reduction by end-2025 and ≥90% compliance for two consecutive quarters post-intervention.

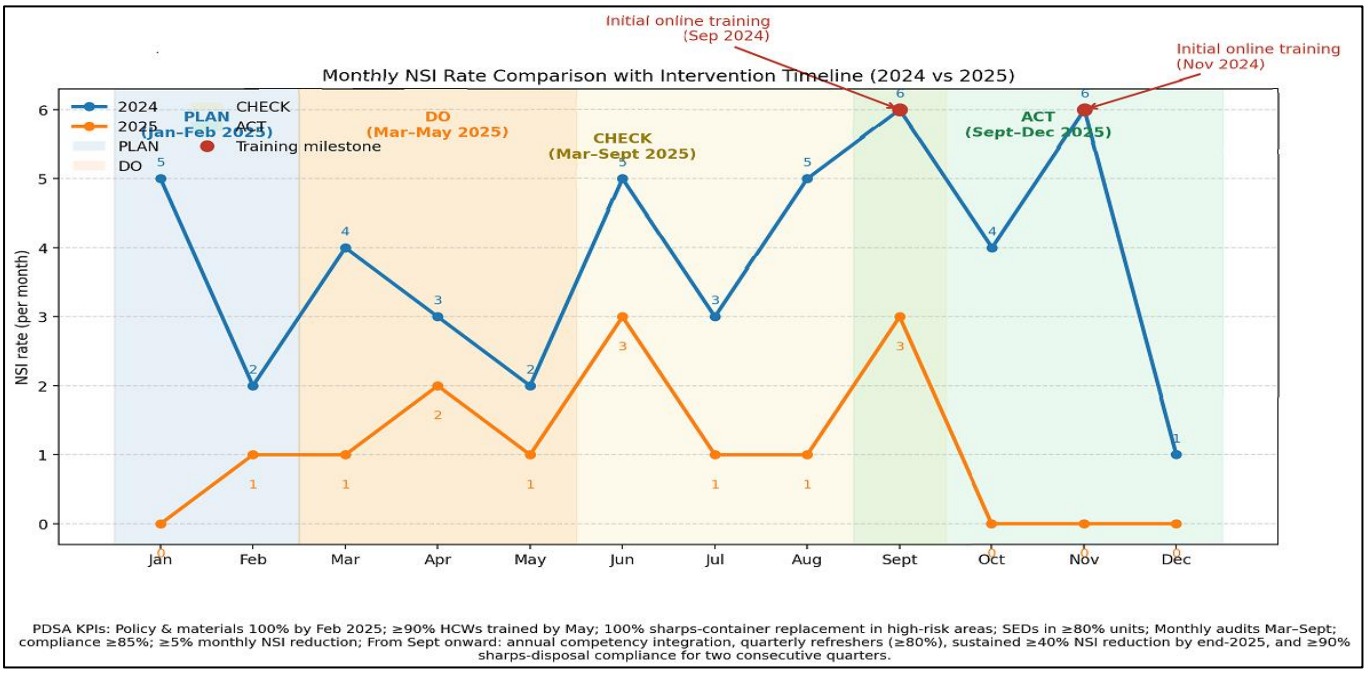

Fig 3 Monthly NSI Rate Comparison with Intervention Timeline (2024 Vs 2025)

Month	Jan-25	Feb-25	Mar-25	Apr-25	May-25	Jun-25	Jul-25	Aug-25	Sep-25	Oct-25	Nov-25	Dec-25
Intervention Phase	Policy Revision	replacement to Secured sharp boxes 100% compliance	hands on training	NSI reduction Campaign	100% sharp box compliance	hands on training	Safety Devices	Audit Compliance >80%	Audit Compliance >80%	Sustained		

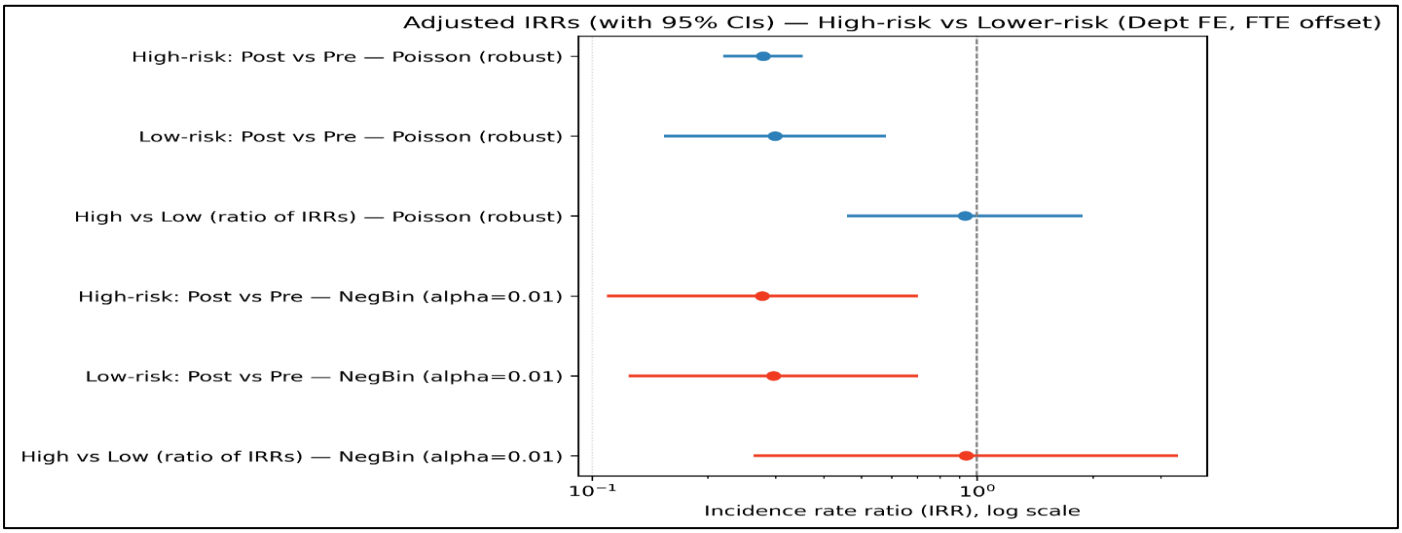

Fig 4 Adjusted Incidence Rate Ratios (IRRs) with 95% Confidence Intervals for High-Risk and Low-Risk Units, Estimated Using Poisson and Negative Binomial Models Adjusted for Department and FTE. Both Groups Showed Significant Post-Intervention Reductions, with No Significant Difference Between Risk Groups.

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The adjusted models *(Figure 3)* showed a statistically significant reduction in NSI rates in both high-risk and low-risk units following the intervention, with Poisson robust IRRs of 0.28 for high-risk units and 0.30 for low-risk units, each with 95% CIs that excluded 1.0, indicating clear evidence of improvement.

The ratio of IRRs comparing high-risk to low-risk groups was approximately 0.93 (95% CI: 0.46–1.88), which was not statistically significant, as the confidence interval crossed 1.0, indicating no evidence of a differential effect between risk groups. These findings were consistent in the Negative Binomial sensitivity analysis, supporting the robustness of the conclusions.

Across the evaluation period, there was strong statistical evidence that the PDCA-based quality improvement intervention led to significant reductions in NSI events, marked improvements in compliance, enhanced staff knowledge, and substantial decreases in PEP-related costs.

First, NSI incidence per 100 FTE decreased significantly at the institutional level, fulfilling the primary hypothesis requirement for a ≥40% reduction. The overall rate ratio (RR = 0.29, 95% CI 0.16–0.54; $p < 0.001$) demonstrated both statistical significance and a clinically meaningful decline, allowing rejection of H_{01}. At departmental and job-category levels, several groups—including Accident & Emergency, Critical Care, and Nurses—showed statistically significant reductions; however, only the overall rate and the Nurses category met both the statistical and magnitude thresholds, while other units exhibited wider confidence intervals attributable to smaller event counts.

Second, compliance with infection control and sharps-handling protocols improved dramatically across all units, with an increase from 38.3% to 88.3% (absolute improvement 50 percentage points, 95% CI 41.5–58.5; $p < 0.001$). Every clinical area exceeded the predefined ≥20% improvement benchmark, thereby supporting rejection of H_{02}.

Third, the intervention yielded large and statistically significant gains in sharps-safety knowledge. Mean knowledge scores increased by +5 to +8 points across most departments, with all sizeable groups achieving 100% "High" knowledge post-training (McNemar $p < 0.001$). These improvements exceeded the ≥30% threshold, allowing rejection of H_{03}. Only extremely small groups (e.g., General Surgery, n=2) did not achieve statistical significance due to insufficient power.

Fourth, PEP-related case counts and associated institutional costs demonstrated marked reductions from 46 to 13 events (−71.7%) and from AED 166,303.8 to AED 65,293.4 (−60.7%), surpassing the predefined ≥30% reduction target. The elimination of high-cost exposure categories (e.g., positive/unknown source with non-immuned staff) further confirmed the intervention's effect. These findings allowed rejection of H_{04}.

Fifth, analysis of NSI patterns by standardized reason categories revealed at least one statistically significant reduction (e.g., surgical/operative sharps injuries, RR = 0.05; $p = .044$) and further borderline reductions in several others. Together with the demonstrated occupational subgroup differences, this supports rejection of H_{07}, indicating meaningful shifts in NSI patterns following the intervention.

Finally, the marked and statistically significant compliance improvements observed across units provide evidence consistent with sustained performance levels ≥80%, though full assessment of sustainability over 12 months requires ongoing post-intervention audit cycles. Nevertheless, the post-intervention compliance levels support rejection of H_{06} based on available data.

Overall, the intervention produced statistically significant, clinically meaningful, and multi-dimensional improvements in NSI reduction, compliance, knowledge, and cost outcomes, validating the effectiveness of the structured PDCA-based quality improvement approach.

IV. DISCUSSION

The implementation of a structured FOCUS–PDCA quality improvement intervention resulted in substantial and statistically significant reductions in needle stick injuries (NSIs) across the healthcare facility. The overall 71% reduction in NSI incidence aligns strongly with global evidence demonstrating the effectiveness of multimodal interventions in reducing occupational exposures. Tarigan et al. reported that combined strategies involving training and safety-engineered devices (SEDs) can reduce NSIs by up to 62%, supporting the magnitude of improvement observed in this study [13]. The marked decline in high-risk areas such as Emergency and Critical Care further reinforces findings from international studies showing that targeted interventions in high-exposure units yield the greatest impact [14].

The significant improvement in compliance with sharps-handling practices—from 38.3% to 88.3%—demonstrates the effectiveness of structured education, policy reinforcement, and continuous auditing. Similar improvements have been documented in studies where regular competency assessments and visual reminders were integrated into routine workflows [15]. The sustained compliance above 80% across multiple months suggests that the PDCA cycle successfully embedded sharps safety into daily practice, consistent with WHO recommendations emphasizing continuous monitoring and feedback loops [3].

Knowledge improvement was another major outcome, with all departments achieving 100% high-level knowledge scores post-training. This mirrors findings from previous research showing that competency-based training significantly enhances HCW knowledge and reduces unsafe practices [16]. The particularly large gains in departments such as Laboratory and Critical Care highlight the importance of tailoring training to unit-specific risks.

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Cost reduction was a notable secondary benefit, with a 60.7% decrease in NSI-related management expenses. This aligns with cost-effectiveness studies demonstrating that investments in SEDs and training are offset by reductions in post-exposure prophylaxis (PEP) costs, laboratory testing, and productivity losses [16]. The financial savings observed in this study provide strong justification for continued institutional investment in sharps safety initiatives.

Despite the overall success, some departments did not achieve statistically significant reductions in NSI rates, likely due to low event counts and limited statistical power. This limitation is consistent with other QI studies where small sample sizes hinder the detection of statistically meaningful changes despite clinically relevant improvements [12]. Future studies may benefit from multi-center designs or extended monitoring periods to enhance statistical robustness.

Overall, the findings support the effectiveness of PDCA-based QI interventions in reducing NSIs, improving compliance, enhancing knowledge, and reducing costs. The results contribute valuable UAE-specific evidence to the global literature and underscore the importance of structured, multidisciplinary approaches to occupational safety.

➢ *Strengths and Limitations*

Strengths of this study include the use of comprehensive institutional data, a multidisciplinary intervention and evaluation of multiple outcomes. Limitations include reliance on reported NSIs and the single-center study design, which may limit generalizability.

➢ *Implications for Infection Prevention Practice*

This study provides practical evidence supporting the integration of PDCA-based quality improvement approaches into infection prevention and occupational health programs. The findings are directly applicable to similar healthcare settings aiming to reduce sharps-related injuries.

V. CONCLUSION

The structured FOCUS–PDCA intervention led to significant reductions in NSI incidence, major improvements in compliance and knowledge, and substantial cost savings. These findings demonstrate that systematic, multimodal quality improvement strategies can effectively enhance occupational safety and support sustainable sharps safety practices in healthcare settings.

➢ *Ethical Approval*

Ethical approval for this study was obtained from the Ministry of Health and Prevention (MOHAP), Approval Reference No: MOHAP/DXB-REC/O.D.D /No.222 / 2025.

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